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REMOTE MAINTENANCE SYSTEMS REQUIREMENTS ARE BEING DEVELOPED TO PROVIDE DESIGN GUIDELINES FOR MACHINE COMPONENTS, TO DEFINE MAINTENANCE INTERFACES, AND TO QUANTIFY MAINTENANCE EQUIPMENT AND PROCEDURES NEEDED*

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June 21, 1988

PRINCETON PLASMA PHYSICS LABORATORY

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PPPL

3-PART PRESENTATION

1. MAINTENANCE REQUIREMENTS

   - DESIGN REQUIREMENTS FOR DISASSEMBLY & MAINTENANCE
   - INTERFACE REQUIREMENT TABLES
     - PHYSICAL CHARACTERISTICS
     - RADIATION CHARACTERISTICS
     - MAINTENANCE CHARACTERISTICS

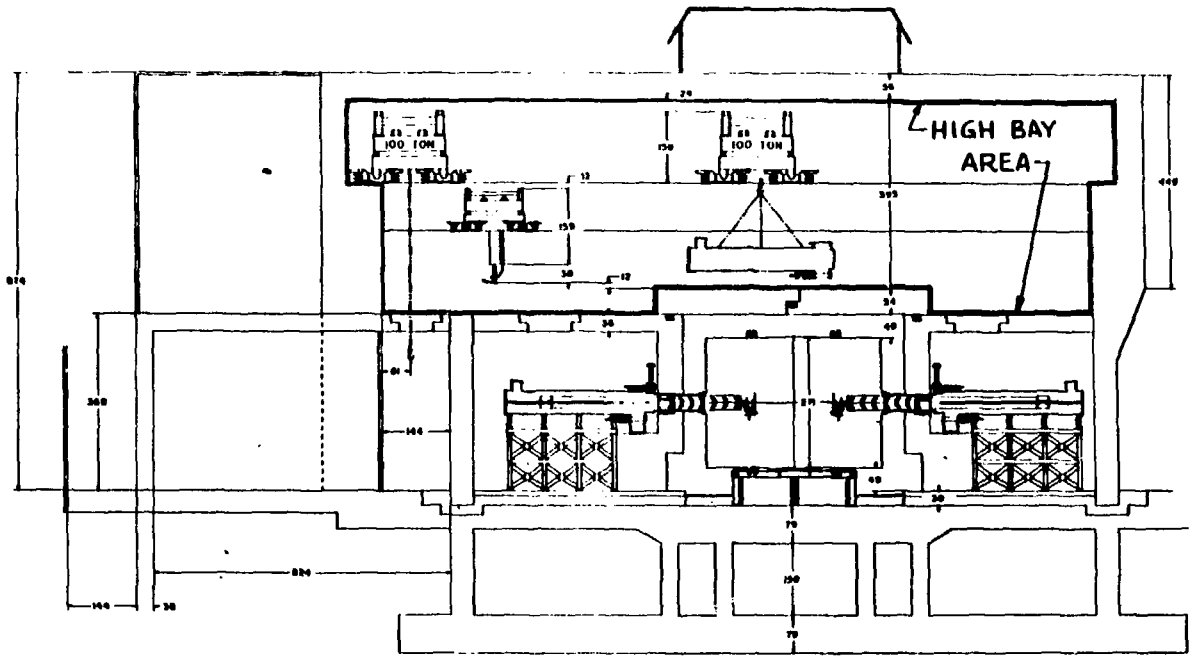
2. INTERFACE BETWEEN WBSI & K FOR MANIPULATOR COMMONALITY

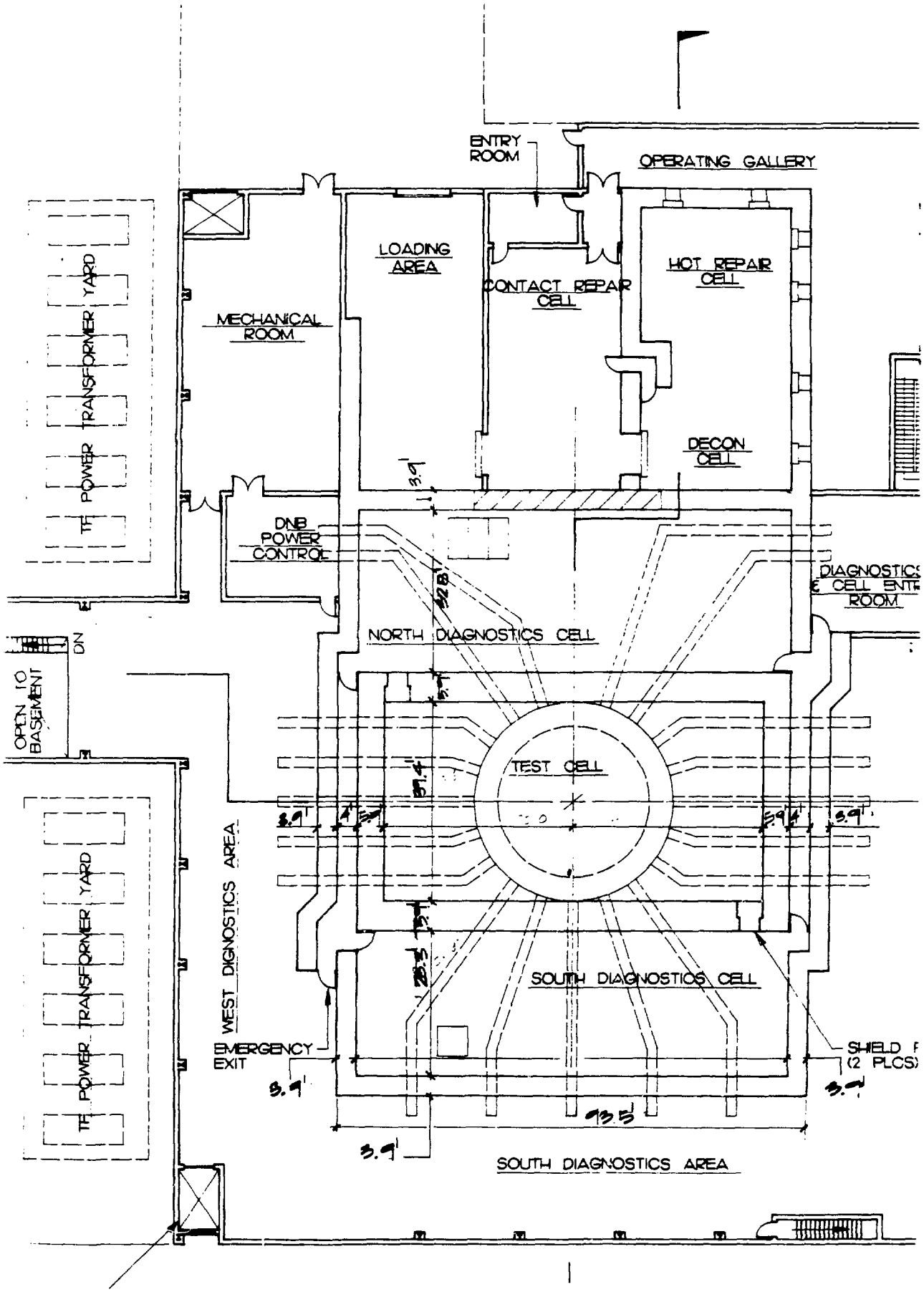
3. R/M DESIGN MANUAL

THE MAINTENANCE SYSTEM REQUIREMENTS ENCOMPASS ALL COMPONENTS AND SUBCOMPONENTS WITHIN THE SHIELDED FACILITY.

- **TEST CELL (NORTH, CENTER, AND SOUTH)**
- **BASEMENT**
- **HIGH BAY**
- **ROOF LABORATORY**
- **REPAIR CELLS (DECON, HOT CELL, AND CONTACT REPAIR CELL)**

THE REQUIREMENTS INCLUDE REMOTE AND HANDS-ON MAINTENANCE.



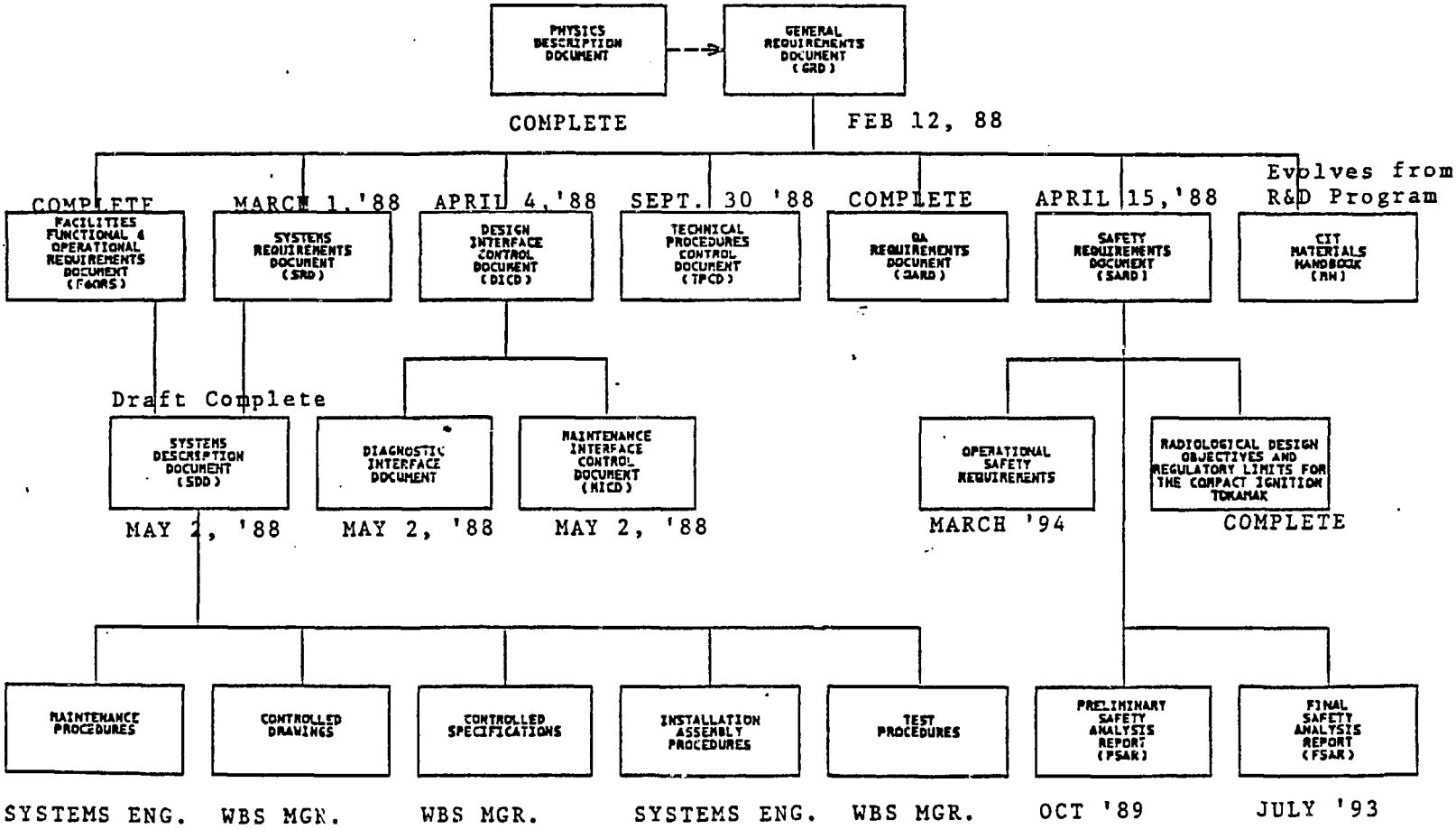

ENTRY ROOM
OPERATING GALLERY
LOADING AREA
CONTACT REPAIR CELL
HOT REPAIR CELL
MECHANICAL ROOM
DECON CELL
DNB POWER CONTROL
DIAGNOSTICS CELL ENTR ROOM
NORTH DIAGNOSTICS CELL
TEST CELL
WEST DIGNOSTICS AREA
SOUTH DIAGNOSTICS CELL
EMERGENCY EXIT
SHIELD (2 PLCS)
SOUTH DIAGNOSTICS AREA
TF POWER TRANSFORMER YARD
OPEN TO BASEMENT
3.9'
93.5'

WBS ELEMENTS WHICH ARE AFFECTED:

B	DIVERTOR SYSTEM
C	FIRST WALL SYSTEM
D	VACUUM VESSEL SYSTEM
E	SHIELDING SYSTEM
F	TF COIL SYSTEM
G	PF COIL SYSTEM
H	TOKAMAK STRUCTURE SYSTEM
I	IN-VESSEL REMOTE MAINTENANCE SYSTEM
J	DIAGNOSTICS SYSTEM
K	EX-VESSEL REMOTE MAINTENANCE SYSTEM
L	ICH SYSTEM
M	ECH SYSTEM
N*	ELECTRICAL POWER SYSTEM
O	I&C
P	WATER COOLING SYSTEM
Q	CRYOGENIC SYSTEM
R	T2 SUPPLY AND GAS FUELING SYSTEM
S	VACUUM PUMPING SYSTEM
T	CONVENTIONAL FACILITIES
U	RADIATION MONITORING AND SAFETY
V	PELLET FUELING SYSTEM

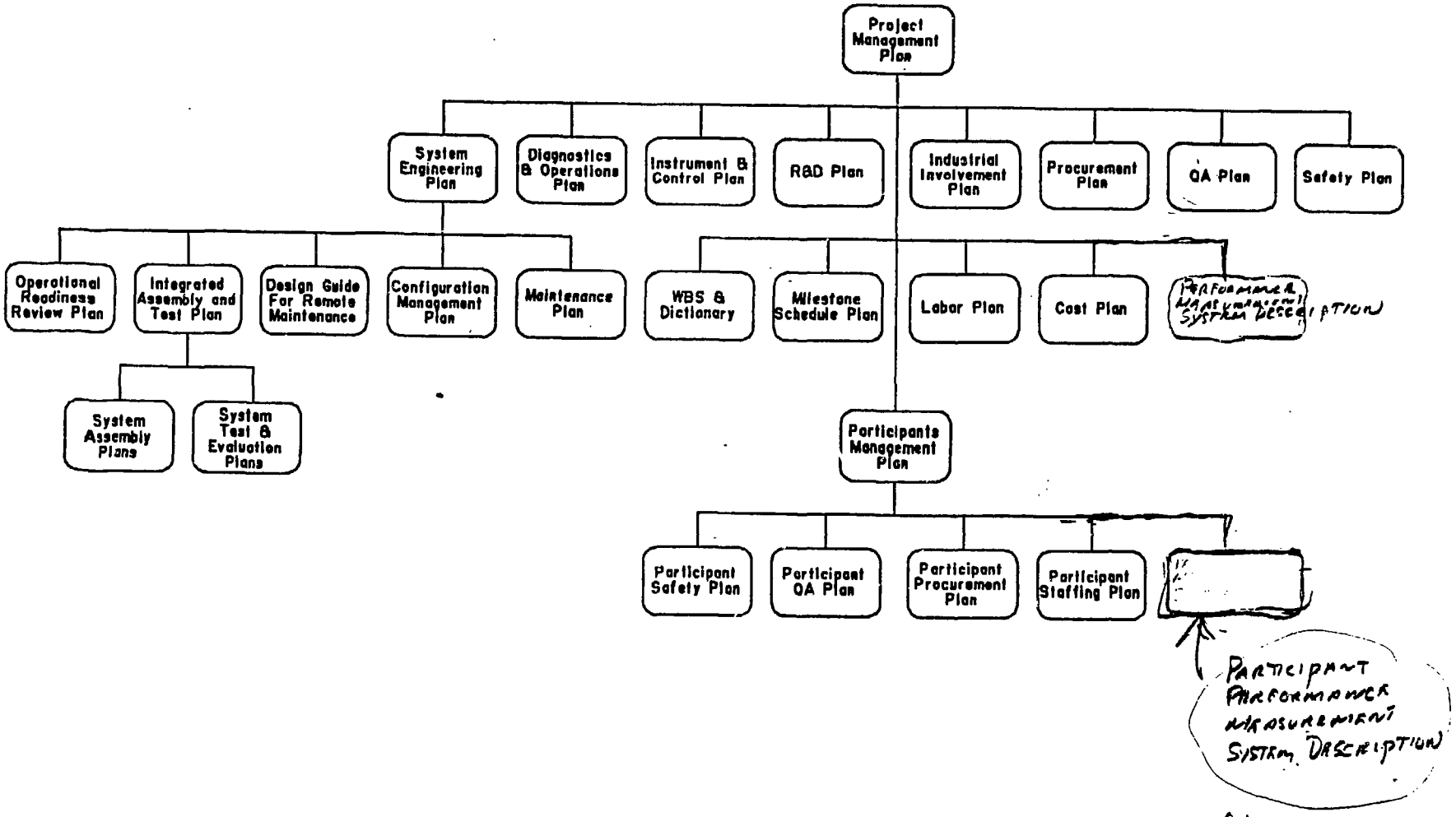
*NOT AFFECTED

CIT PROJECT
DESIGN CONTROL DOCUMENTS



CIT PROJECT

PLAN TREE



THE PRESENT WORK INCLUDES:

DESIGN REQUIREMENTS FOR DISASSEMBLY AND MAINTENANCE

- TOP LEVEL GUIDELINES TO ENSURE THAT COMPONENTS IN EACH WBS ELEMENT ARE MAINTAINABLE
- ESTABLISH CERTAIN RESPONSIBILITIES SUCH AS THE DESIGN AND FABRICATION OF HANDLING FIXTURES AND USE OF THE REMOTE MAINTENANCE DESIGN MANUAL.

THESE WILL BE INCORPORATED INTO THE SYSTEMS REQUIREMENTS DOCUMENT (SRD)

WBS B: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents of the Divertor System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K and I.

2. The components must be designed to permit access for the [illegible] must be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K and I.

5. The component design shall include provisions for handling fixtures for extracting and lifting. The handling fixtures shall be the responsibility of WBS I and K.

6. Components that are expected to be repaired (either remotely or hands-on) must be sub-modularized to permit easy replacement of worn parts.

7. All components that are in, or part of, the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

8. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut up) to simplify waste packaging and disposal.

WBS C: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents of the First Wall System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K and I.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K and I.

5. The component design shall include provisions for handling fixtures for extracting and lifting. The handling fixtures shall be the responsibility of WBS I and K.

6. Components that are expected to be repaired (either remotely or hands-on) must be sub-modularized to permit easy replacement of worn parts.

7. All components that are in, or part of the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

8. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut up) to simplify waste packaging and disposal.

WBS D: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that non-permanent components and subcomponents of the Vacuum Vessel System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K and I.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K and I.

5. The component design shall include provisions for handling fixtures for extracting and lifting. The handling fixtures shall be the responsibility of WBS I and K.

6. Components that are expected to be repaired (either remotely or hands-on) must be sub-modularized to permit easy replacement of worn parts.

7. All components that are in, or part of the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

8. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut up) to simplify waste packaging and disposal.

WBS E: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Shielding System can be assembled and disassembled using remote handling equipment (or long-handled tools where appropriate).

1. All components must be modular in design and provide access for interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The modules must be designed to permit access for the inspection of critical areas; these areas will be determined by the WBS Element which is being shielded, and reviewed by WBS E and the MIG.

3. All modules that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in a shield module that is remotely handled (e.g. bolts, nuts, lifting bails, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component design must include any mechanisms needed for extracting or moving a module from its installed position (e.g. motorized drives, rollers, bails etc.), and be compatible with remote handling needs.

6. The component designer is responsible for providing special handling fixtures for moving and lifting shield modules. Although the fixtures are the responsibility of WBS E, they may be commissioned to WBS K for design and fabrication.

7. All modules must be designed with smooth surfaces, and finishes which are compatible with decontamination as outlined in the Remote Maintenance Design Manual.

WBS F: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that certain components and subcomponents which make up the TF Coil System can be inspected while installed, disassembled where necessary using remote handling equipment, and maintained in situ for limited operations.

1. The TF coils are designed to be permanent installations in the machine and are not replaceable; a failure within the coil is outside the scope of these requirements. However, the components which couple directly to the coils must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS F, they may be commissioned to WBS K for design and fabrication.

6. Components that are expected to be replaced must be sized to fit into the decon cell.

WBS G: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the PF Coil System can be inspected while installed, disassembled where necessary using remote handling equipment, and maintained in situ for limited operations.

1. The PF coils are designed to be permanent installations in the machine and are generally considered not to be replaceable. However, the external coils above the midplane should be designed with demountable structural interfaces.

2. The ohmic heating (OH) solenoid must be designed to be replaceable as a module using overhead lifting.

3. The components which couple directly to the coils must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

4. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

5. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

6. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

7. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS G, they may be commissioned to WBS K for design and fabrication.

8. Components that are expected to be replaced must be sized to fit into the decon cell.

WBS H: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Tokamak Structure System can be inspected while installed, disassembled where necessary using remote handling equipment, and maintained in situ for limited operations.

1. The tokamak structure is designed to be a permanent installation in the machine and is considered not to be replaceable.

2. The structure shall be designed to provide access for remotely inspecting and replacing mechanical joints (bolts and nuts).

3. The structure must be designed to permit access for the inspection of critical areas; these will be determined by the component designers of WBS elements that interface/penetrate the structure and WBS H, and reviewed by the Maintenance Integration Group (MIG).

4. All structural components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

5. All hardware used in a structural component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

6. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS H, they may be commissioned to WBS K for design and fabrication.

WBS I: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents of the In-Vessel Remote Maintenance System can be used to inspect and disassemble in-vessel components for maintenance in either a hot cell or contact repair cell.

1. Inspection viewing manipulator systems shall be provided to permit rapid inspection of critical features of all in-vessel components.

2. Tools and fixtures shall be provided as necessary to accomplish remote removal and replacement or repair operations, as applicable, of all in-vessel components and features for which remote maintenance is specified.

3. ABM/Servo-manipulator systems shall be provided to position the tools and fixtures as necessary to accomplish the specified in-vessel remote maintenance tasks.

4. The Servo-manipulator system shall be detachable from the ABM and means shall be provided to move it in and out of a transport cask.

5. All tools and fixtures required for in-vessel remote maintenance shall be transportable by the ABM/Servo-manipulator system in and out of the vessel from/to a transport cask.

6. All in-vessel components requiring removal and replacement shall be transportable by the ABM/Servo-manipulator system in and out of the vessel from/to a transport cask.

7. The transport system shall permit moving the transport casks back and forth from the ABM to the hot cell, contact repair cell or tool storage area.

8. All tools, fixtures and other remote maintenance equipment that might become contaminated must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

9. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassemble (or cut up) to simplify waste packaging and disposal.

10. All remote handling devices shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual, as applicable.

WBS J: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Diagnostics System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K and I.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component design must include the mechanisms needed for extracting a module from its installed position (e.g. motorized drives, rollers, etc.), and be compatible with remote handling needs.

6. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS J, they may be commissioned to WBS K (or I if appropriate) for design and fabrication.

7. Components that are expected to be repaired (either remotely or hands-on) must be sub-modularized to permit easy replacement of worn parts.

8. All components that are in, or are part of the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

9. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut-up) to simplify waste packaging and disposal.

WBS K: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Ex-Vessel Remote Maintenance System can be inspected, and maintained in the contact repair cell. The equipment will never be operated in a neutron environment.

1. All maintenance equipment must be modular in design with accessible, simple interfaces (mechanical, electrical, or coolant) for ease of disassembly, maintenance, and use of that equipment.

2. Working envelopes to establish clearances for equipment and tools shall be developed by WBS K and reviewed by the Maintenance Integration Group (MIG).

3. Maintenance equipment must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

4. Manipulator to transporter interfaces shall be designed for remote decoupling using the approaches and guidelines in the Remote Maintenance Design Manual.

5. All hardware that is remotely handled (e.g. bolts, nuts, couplings, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG.

6. The equipment designers are responsible for providing special handling fixtures for WBS K equipment, and general purpose handling fixtures for other WBS components.

7. Components that are expected to be repaired or replaced frequently must be sub-modularized to permit easy replacement of worn parts.

8. The bridge-mounted manipulator/transporter, the floor-based mobile manipulator/transporter, and all other maintenance equipment and tools must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

9. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly to simplify waste packaging and disposal.

WBS L: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the ICRH Heating System can be inspected while installed, disassembled using remote handling equipment, and maintained in the hot cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component design must include the mechanisms needed for extracting a module from its installed position (e.g. motorized drives, rollers, etc.), and be compatible with remote handling needs.

6. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS L, they may be commissioned to WBS K for design and fabrication.

7. Components that are expected to be repaired must be sub-modularized to permit easy replacement of worn parts.

8. All components that are in, or are part of the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

9. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut-up) to simplify waste packaging and disposal.

WBS M: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the ECRH Heating System can be inspected while installed, disassembled using remote handling equipment, and maintained in the hot cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component design must include the mechanisms needed for extracting a module from its installed position (e.g. motorized drives, rollers, etc.), and be compatible with remote handling needs.

6. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS M, they may be commissioned to WBS K for design and fabrication.

7. Components that are expected to be repaired must be sub-modularized to permit easy replacement of worn parts.

8. All components that are in, or are part of the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

9. Non-repairable components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut-up) to simplify waste packaging and disposal.

WBS 0: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that the interfaces with the Instrumentation and Control System provide for safe maintenance operations in the test cell (north, center, and south), high bay, basement, and roof laboratory areas.

1. The I&C group shall provide the following safety interlocks when the machine is operational:

   - o sliding roof shield cannot be opened,
   - o personnel entry into the north and south cells, the high bay, the basement, and the roof lab areas is prevented,
   - o maintenance equipment in those same areas is rendered inoperable, including the T/C crane.

2. The I&C group shall provide the following safety interlocks when the machine is not operational:

   sliding roof shield closed, one day after shutdown

   - o personnel access in the north and south cells, the high bay, the basement, and the roof lab areas, with the roof shield inoperable,
   - o unrestricted use of remotely operated maintenance equipment.

   sliding roof shield closed, at shutdown

   - o no personnel access in those same areas,
   - o unrestricted use of remotely operated maintenance equipment.

   sliding roof shield open

   - o no personnel access in those same areas,
   - o unrestricted use of remotely operated maintenance equipment.

WBS P: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Water Cooling System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be designed with accessible interfaces to permit remote disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware and joints used on a component that is remotely handled (e.g., bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS P, they may be commissioned to WBS K for design and fabrication.

6. Components that are expected to be repaired (either remotely or hands-on) must be sub-modularized to permit easy replacement of worn parts.

7. All components that are potential traps for activated particular matter or are exposed to tritium, must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

8. Non-repairable, activated components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut-up) to simplify waste packaging and disposal.

WBS Q: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Cryogenics System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be designed with accessible interfaces to permit remote disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. Insulation located at demountable joints must be designed to be readily removed and reinstalled, and be capable of remote handling where required.

4. All components and joints that require remote handling shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

5. All hardware used on a component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

6. All components that are potential traps for activated particular matter or are exposed to tritium, must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

7. Non-repairable, activated components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut-up) to simplify waste packaging and disposal.

WBS R: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Tritium Supply and Gas Fueling System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be designed with accessible interfaces to permit remote disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. Insulation located at demountable joints must be designed to be readily removed and reinstalled, and be capable of remote handling where required.

4. All components and joints that require remote handling or glovebox operations shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

5. All hardware used on a component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

6. All components that are exposed to tritium must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

7. Non-repairable, activated components that are expected to be routinely disposed of should be designed for ease of disassembly (or cut-up) to simplify waste packaging and disposal.

WBS S: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Vacuum Pumping System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be modular in design with accessible interfaces (mechanical, electrical, or coolant) to permit disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. All components that require remote handling or glovebox operations shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

4. All hardware used in the component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

5. The component designer is responsible for providing special handling fixtures for extracting and lifting. Although the fixtures are the responsibility of WBS S, they may be commissioned to WBS K for design and fabrication.

6. Components that are expected to be repaired (either remotely or hands-on) must be sub-modularized to permit easy replacement of worn parts.

7. All components that are in, or are part of the vacuum boundary of the plasma chamber must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

8. Non-repairable or non-reusable components that are expected to be routinely disposed of should be designed for ease of disassembly or handling to simplify waste packaging and disposal.

WBS T: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that interfaces with the Conventional Facilities System provide for maintenance operations in the test cell (north, center, and south), high bay, basement, and roof laboratory areas.

1. The facilities group shall provide the following maintenance related equipment:

   - o test cell bridge crane,
   - o north and south cell bridge cranes.

2. The control systems for the cranes will be integrated and interfaced into the overall remote handling control system and be the responsibility of WBS K.

3. The facilities group shall provide adequate pathways and ingress/egress from the operating areas listed above to the decon and repair cell areas. These will be developed jointly with WBS K.

WBS U: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that the Radiation Monitoring and Safety System provides for monitored maintenance operations in the test cell (north, center, and south), repair cells, high bay, basement, and roof laboratory areas.

1. Radiation monitors shall be provided along all maintenance pathways and at all ingress/egress to the cells listed above.

2. All machine components that are moved from their installed position must be radiation surveyed before entering the decon cell.

3. All machine components that are moving from the repair cell area must be radiation surveyed after decon.

WBS V: Design Requirements for Disassembly and Maintenance

Listed below are the fundamental design requirements to ensure that components and subcomponents which make up the Pellet Fueling System can be inspected while installed, disassembled where remote handling equipment is required, and maintained either in the hot cell or contact repair cell.

1. All components which couple directly to the machine must be designed with accessible interfaces to permit remote disassembly and handling. Interface clearances shall be developed in conjunction with the Maintenance Integration Group (MIG) and WBS K.

2. The components must be designed to permit access for the inspection of critical areas; these will be determined by the component designer and reviewed by the MIG.

3. Insulation located at demountable joints must be designed to be readily removed and reinstalled, and be capable of remote handling where required.

4. All components and joints that require remote handling or glovebox operations shall be designed using the approaches and guidelines in the Remote Maintenance Design Manual.

5. All hardware used on a component that is remotely handled (e.g. bolts, nuts, couplings, pipes, connectors, etc.) is limited to the listings of standard hardware in the Remote Maintenance Design Manual. Deviations from these standards must be approved by the MIG and WBS K.

6. All components that are exposed to tritium must be designed for decontamination as outlined in the Remote Maintenance Design Manual.

7. Non-repairable, activated components that are expected to be routinely disposed of should be designed for ease of disassembly to simplify waste packaging and disposal.

PRESENT WORK (CONT.)

INTERFACE REQUIREMENTS (3 TABLES)

TABLE 1. PHYSICAL CHARACTERISTICS
TABLE 2. RADIATION CHARACTERISTICS
TABLE 3. MAINTENANCE CHARACTERISTICS

INTERFACE CONTROL (NOT YET STARTED)

- CONSIST PRIMARILY OF DRAWINGS TO ESTABLISH ACCESS, CLEARANCE, AND MANIPULATOR/TOOL INTERFACES

THESE WILL BE INCORPORATED INTO THE MAINTENANCE INTERFACE CONTROL DOCUMENT (MICD).

THE VACUUM PUMPING SYSTEM REPRESENTS THE MOST COMPLETE TABULATION OF INTERFACE REQUIREMENTS TABLES

THE SYSTEM CONSISTS OF:

- √ o TORUS ULTRA-HIGH V.P. SYSTEM
- o DIAGNOSTIC HIGH V.P. SYSTEM
- √ o FORE AND ROUGHING PUMP SYSTEM
- o VACUUM SYSTEM BAKEOUT
- √ o PUMP DUCTS
- o DIFFERENTIAL PUMPING AND LEAK DETECTION
- o LOCAL I&C
- o CRYOSTAT PUMPING SYSTEM

Table 1. Interface Requirements: Physical Characteristics

WBS Element	Size (in.)	Weight (lb)	Containment Device	Handling Devices	Pathway
Torus Vaccum Pumping Duct Assembly					
Duct 1	35 x 14 x 60	TBD	Shielded Cask	T/C Crane	High bay, decon, H/C
Duct 2	320 x 480	6400	Shielded Cask	T/C Crane	High bay, decon, H/C
Duct 3	116 x 400	2000	Shielded Cask	Cart	Basement, N elevator, decon, H/C
Duct 4	120 x 400	2200	Cover plate/ T_2 shroud		Basement, N elevator, decon, CRC
Duct 5	48 x 120	300			
Valve 1 (to ADS)	29 x 8 x 6	50			
Valve 2 (to rough.)	29 x 8 x 6	50			
TMP Assembly (2000 ℓ/s)					
TMP 1	21 x 150	242	Cover plate/ T_2 shroud	Cart	Basement N elevator, decon, CRC
TMP 2	21 x 150	242			
TMP 3	21 x 150	242			
TMP 4	21 x 150	242			
TMP 5	21 x 150	242			
TMP 6	21 x 150	242			
Valve 1 (in.)	52 x 16 x 4	TBD			
Valve 1 (ex.)	29 x 8 x 6	50	T_2 shroud	Cart	
Valve 2 (in.)	52 x 16 x 4	TBD			
Valve 2 (ex.)	29 x 8 x 6	50			

Table 1. Interface Requirements: Physical Characteristics

WBS Element S	Size (in.)	Weight (lb)	Containment Device	Handling Devices	Pathway
Torus Vacuum Pump. (cont.)					
Valve 3 (in.)	52 x 16 x 4	TBD	T_2 Shroud	Cart	Basement, N elevator
Valve 3 (ex.)	29 x 8 x 6	50			decon, CRC
Valve 4 (in.)	52 x 16 x 4	TBD			
Valve 4 (ex.)	29 x 8 x 6	50			
Valve 5 (in.)	52 x 16 x 4	TBD			
Valve 5 (ex.)	29 x 8 x 6	50			
Valve 6 (in.)	52 x 16 x 4	TBD			
Valve 6 (ex.)	29 x 8 x 6	50			
Mag. Shield 1	29 x 370	3800	None	Port. Crane	N/A
Mag. Shield 2					
Mag. Shield 3					
Mag. Shield 4					
Mag. Shield 5					
Mag. Shield 6					

Table 1. Interface Requirements: ~~Physics~~ Physical Characteristics

WBS Element S	Size (in.)	Weight (lb)	Containment Device	Handling Devices	Pathway
Torus Vac. Pump. (cont.)					
TMP Assembly (300 ℓ/s)					
TMP 1	12 x 80	26	Cover Plate/ T_2 Shroud	Cart	Basement, N elevator decon, CRC
TMP 2	12 x 80	26			
Valve 1 (in.)	29 x 8 x 6	50	T_2 Shroud	Cart	
Valve 1 (ex.)	29 x 8 x 6	50			
Valve 2 (in.)	29 x 8 x 6	50			
Valve 2 (ex.)	29 x 8 x 6	50			
Mag. Shield 1	20 x 240	1400	None	Port. Crane	N/A
Mag. Shield 2	20 x 240	1400	None	Port. Crane	N/A
Scroll Pump Assembly					
Scroll 1	116 x 720	10,500	Cover Plate	T/C Crane	Basement, N cell, decon, CRC
Scroll 2	116 x 720	10,500			
Valve 1 (in.)	29 x 8 x 6	50	T_2 Shroud	Cart	Basement, N elevator, Decon, CRC
Valve 1 (ex.)	29 x 8 x 6	50			
Valve 2 (in.)	29 x 8 x 6	50			
Valve 2 (ex.)	29 x 8 x 6	50			
Valve to holdup	29 x 8 x 6	50			
Valve to stack	29 x 8 x 6	50			

Table 2. Maintenance Requirements: Radiation Characteristics

WBS Element	Activation Level (mr/h)	Contamination	Handling Method
Torus Vacuum Pumping			
Duct Assembly			
Duct 1	>1000	T_2	Remote
Duct 2	>1000	Dust, T_2	
Duct 3	>500 (?)	T_2	
Duct 4	<100 (?)		Limited Hands-on
Duct 5	<1 (?)		Hands-on
Valve 1 (to ADS)	<1	T_2	Hands-on
Valve 2 (to rough.)	<1		
TMP Assembly (2000 (2000 ℓ/s)			
TMP 1-6	<1	T_2	Hands-on
Valve 1-6 (in.)			
Valve 1-6 (ex.)			
Magnetic Shield 1-6	0	None	Hands-on

Table 2. Interface Requirements: Radiation Characteristics

W3S Element S	Activation Level (mr/h)	Contamination	Handling Method
TMP Assembly (300 ℓ/s)			
TMP 1-2	<1	T_2	Hands-on
Valve 1-2 (in.)	<1	T_2	
Valve 1-2 (ex.)	<1	T_2	
Magnetic Shield 1-2	0	None	
Scroll Pump Assembly			
Scroll 1-2	<1	T_2	Hands-on
Valve 1-2 (in.)	<1		
Valve 1-2 (ex.)	<1		
Valve to holdup	<1		
Valve to stack	<1		

Table 3. Maintenance Requirements: Maintenance Characteristics

WBS Element	Component (m) Lifetime	Inspection (w) Frequency	Remote Testing	Mockup	Failure Recovery
Torus Vacuum Pumping					
Duct Assembly					
Duct 1	Lifetime	N/A	Leak Det.	Y	In situ repair
Duct 2				Y	
Duct 3				N	TBD
Duct 4			N/A		In situ repair
Duct 5					
Valve 1 (to ADS)	TBD				Replace
Valve 2 (to rough)	TBD				
TMP Assembly (2000 ℓ/s)					
TMP 1-6	TBD	4 (?)	N/A	N	Replace
Valve 1-6 (in.)	TBD	TBD			
Valve 1-6 (ex.)	TBD	TBD			
Magnetic Shield 1-6	Lifetime	N/A			N/A

Table 3. Interface Requirements: Maintenance Characteristics

WBS Element S	*Component (m) Lifetime*	*Inspection (w) Frequency*	*Remote Testing*	*Mockup*	*Failure Recovery*
TBP Assembly (300 ℓ/s)					
TMP 1-2	*TBD*	*4 (?)*	*N/A*	*N*	*Replace*
Valve 1-2 (in.)	*TBD*	*TBD*			
Valve 1-2 (ex.)	*TBD*	*TBD*			
Magnetic Shield 1-2	*Lifetime*	*N/A*			*N/A*
Scroll Pump Assembly					
Scroll 1-2	*Lifetime*	*None*	*N/A*	*N*	*Replace*
Valve 1-2 (in.)	*TBD*	*TBD*			
Valve 1-2 (ex.)					
Valve to holdup					
Valve to stack					

SYSTEMS REQUIREMENTS FOR WBS I AND K ARE BEING INVESTIGATED FOR MANIPULATOR COMMONALITY

* ORNL REVIEWED 56 SBIR "RM-10" MANIPULATOR DESIGN REQUIREMENTS

* ORNL HAS COMMENTED ON 21
  - -FORCE REFLECTION
  - -RM-10 WRIST CONFIGURATION
  - -KINEMATICS
  - -CONTROLS

AN INTERFACE MEETING IS SCHEDULED FOR JUNE 28 AT THE REMOTE TECHNOLOGY CORPORATION HEADQUARTERS

* GA AND ORNL TO ATTEND

ONE OF THE KEY ISSUES IS THE REQUIREMENT TO DEVELOP A VACUUM RATED MANIPULATOR SYSTEM.

- DIFFICULT DESIGN (JET, REMOTEC)
- WHAT DOES IT BUY US IN VIEW OF
  - HIGH BAKEOUT TEMPERATURE
  - EXPERIENCE WITH FW TILES (TFTR, JET)

I WILL QUANTIFY THE ABOVE FOR THE JUNE 28, 1988, MEETING.

REMOTE MAINTENANCE DESIGN MANUAL IS BEING DEVELOPED

- ROUGH DRAFT PUT ASIDE 5 WEEKS AGO TO WORK ON MAINTENANCE REQUIREMENTS
- SYSTEMS ENGINEERING ACTIVITY WHICH IS BEING SUPPORTED BY WBS K

NEAR-TERM PLAN

- RETURN TO DESIGN MANUAL JULY 1
- JULY 15 ISSUE SKELETAL MANUAL
  - COORDINATED WITH MACHALEK
- THEREAFTER BEGIN ISSUING "INSERTS" IN MEMO FORM
  - COUPLINGS
  - CONNECTORS,....

OUTLINE

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